tozoids, which may be restored by the addition of dense saline and other solutions. All of the alkaline, animal fluids of moderate viscidity favor the movements, while the action of acid or of very dilute solutions is unfavorable. The movements are suspended by extreme cold, but they return when the ordinary temperature is restored.

Before the age of puberty the seminiferous tubes are much smaller than in the adult, and they contain small, transparent cells, which in their form and arrangement resemble epithelium. As puberty approaches, however, the tubes become larger, and the contents change their character. The walls are then provided with spindle-shaped cells with a nucleated, protoplasmic lining, sending prolongations into the interior of the tube. These prolongations afterward break up into little, rounded bodies called spermatoblasts, a part of each one of which becomes the head of a spermatozoid (Ebner). Between the prolongations, are the so-called spermatic cells. The spermatoblasts send out each one a short process which forms the intermediate segment of the spermatozoid, and from this a long filament is developed, which forms the tail. The spermatozoid is detached when its development is complete.

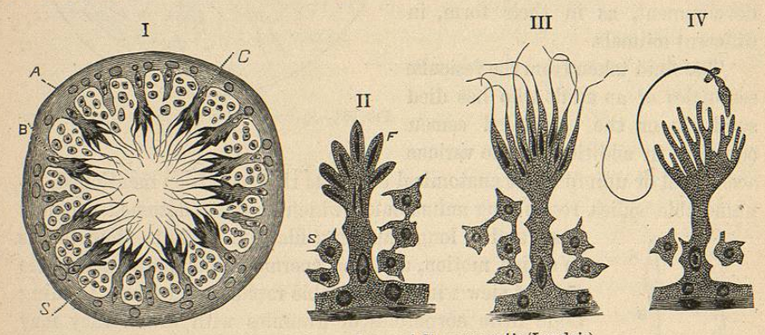

Fig. 290.—*Spermatogenesis; semi-diagrammatic* (Landois).
I, transverse section of a seminal tubule; A, external membrane; B, protoplasmic lining; C, spermatoblast; S, seminal cells.
II, projection with F, spermatoblasts; S, seminal cells.
III, spermatoblasts with spermatozoids not yet detached.
IV, spermatoblasts with a spermatozoid detached.

The spermatozoids are motionless while they are within the testicle, the epididymis or the vasa deferentia, apparently on account of the density of the substance in which they are embedded; for movements are sometimes presented when the contents of the vasa deferentia are examined with the addition of water or of saline solutions. Once in the vesiculæ seminales, and for a certain time after ejaculation, the spermatozoids are in active motion. When the spermatozoids have ceased their movements they are incapable of fecundating the ovum.

The semen, thus developed and mixed with the various secretions before mentioned, is found during adult life and sometimes even in advanced age, and under physiological conditions it contains innumerable spermatozoids in active movement; but if sexual intercourse be frequently repeated at short intervals, the ejaculated fluid becomes more and more transparent,

homogeneous and scanty, and it may consist of a small quantity of secretion from the vesiculæ seminales and the glands opening into the urethra, without spermatozoids and consequently deprived of fecundating properties.

In old men the seminal vesicles may not contain spermatozoids; but this is not always the case, even in very advanced life. Instances are constantly occurring of men who have children in their old age, in which the paternity of the offspring can hardly be doubted. Duplay, in 1852, examined the semen of a number of old men, and found, in about half the number, spermatozoids, normal in appearance and quantity, though in some the vesiculæ seminales contained either none or very few. Some of the persons in whom the spermatozoids were normal were between seventy-three and eighty-two years of age. These observations were confirmed by Dieu, who found spermatozoids in a man eighty-six years of age. The contents of the seminal vesicles, in these cases, were examined twenty-four hours after death. Some of the subjects died of acute, and others, of chronic diseases; but the mode of death did not present any differences in the cases classed with reference to the presence of spermatozoids. As the result of his own and of other recorded observations, Dieu concluded that the power of fecundation often persists for a considerable time after copulation has become impossible on account simply of absence of the power of erection.

CHAPTER XXV.

FECUNDATION AND DEVELOPMENT OF THE OVUM.

General considerations—Fecundation—Changes in the fecundated ovum—Segmentation of the vitellus—Primitive trace—Blastodermic layers—Formation of the membranes—Amniotic fluid—Umbilical vesicle—Formation of the allantois and the permanent chorion—Umbilical cord—Membranæ deciduæ—Formation of the placenta—Uses of the placenta—Development of the ovum—Development of the cavities and layers of the trunk in the chick—Vertebral column—Development of the skeleton—Development of the muscles—Development of the skin—Development of the nervous system—Development of the organs of special sense—Development of the digestive apparatus—Development of the respiratory apparatus—Development of the face—Development of the teeth—Development of the genito-urinary apparatus—Development of the circulatory apparatus—Description of the fœtal circulation.

As far as the male is concerned, coitus is rendered possible by erection of the penis. This may occur before puberty, but at this time intercourse can not be fruitful. Coitus may be impossible in old age, from absence of the power of erection; but spermatozoids may still exist in the vesiculæ seminales, and fecundation might occur if the seminal fluid could be discharged into the generative passages of the female. Coitus may take place in the female before the age of puberty or after the final cessation of the menses, but intercourse can not then be fruitful. There are many instances of conception following what would be called imperfect intercourse, as in cases of unruptured hymen, deformities of the male organs, etc., which show that the actual

penetration of the male organ is not essential, and that fecundation may occur provided the seminal fluid find its way into even the lower part of the vagina. Conception has also followed intercourse when the female has been insensible or entirely passive. Unlike certain of the lower animals, the human subject presents no distinct periodicity in the development of the spermatozoids; but in reiterated connection, an orgasm may occur when the ejaculated fluid has no fecundating properties.

With regard to the mechanism of erection, little remains to be said after the description that has been given of true, erectile tissue, in connection with the physiology of the circulation. The cavernous and spongy bodies of the penis usually are taken as the type of erectile organs. In these parts the arteries are large, contorted, provided with unusually thick, muscular coats, and are connected with the veins by vessels considerably larger than the true capillaries. They are supported by a strong, fibrous net-work of trabeculæ, which contains non-striated muscular fibres; so that when the blood-vessels are completely filled the organ becomes enlarged and rigid. Researches with regard to the nerves of erection show that the vessels of erectile tissues are distended by an enlargement of the arterioles of supply, and that there is not simply a stasis of blood produced by constriction of the veins, except possibly for a short time during the period of greatest excitement. In experiments upon dogs Eckhard discovered a nerve derived from the sacral plexus, stimulation of which produced an increase in the flow of blood through the penis, attended with all the phenomena of erection. This nerve arises by two roots, at the sacral plexus, from the first to the third sacral nerves, and is connected with the genito-spinal centre, in the lower part of the lumbar region of the spinal cord (Budge). In the experiments referred to, by a comparison of the quantity of venous blood coming from the penis before and during the stimulation of the nerve, Eckhard found a great increase during erection. It is probable that in addition to the arterial dilatation, when the penis attains its maximum of rigidity there is a certain degree of obstruction to the outflow of blood, by compression of the veins, and that the rigidity is increased by contraction of the trabecular muscular fibres of the corpora cavernosa. At the climax of an orgasm, the semen is forcibly discharged from the urethra, by spasmodic contractions of the vesiculæ seminales and the ejaculatory muscles. Although this is the physiological mechanism of a seminal discharge, friction of the parts, which usually precedes ejaculation, is not absolutely necessary, as is shown by the occurrence of orgasm during sleep, which is liable to take place in healthy men after prolonged continence.

There are some females, in whom the generative function is performed, even to the extent of bearing children, who have no actual knowledge of a true venereal orgasm; but there are others who experience an orgasm fully as intense as that which accompanies ejaculation in the male. There is, therefore, the important difference in the sexes, that preliminary excitement and an orgasm are necessary to the performance of the generative act in the male, but are not essential in the female. Still there can be scarcely a doubt

that venereal excitement in the female facilitates conception, other conditions being favorable. When excitement occurs in the female there is engorgement of the true erectile tissues and possibly of the convoluted vessels surrounding the internal organs. The neck of the uterus becomes hardened and slightly elongated (Wernich); and it has been observed by Litzmann and others, that there occurs a sudden opening and closing of the os, which exerts more or less suction force. These conditions, however, are not essential to fecundation, although they may exert a favorable influence upon the penetration of spermatozoids and may at certain times determine the rupture of a Graafian follicle.

The spermatozoids, once within the cervix uteri, and in contact with the alkaline mucus, which increases the activity of their movements, may pass through the uterus into the Fallopian tubes, and even to the surface of the ovaries. Precisely how their passage is effected, it is impossible to say. It can only be attributed to the movements of the spermatozoids themselves, to capillary action, and to a possible peristaltic action of the muscular structures; but these points have not as yet been subjects of positive demonstration. As regards the human female, it is impossible to give a definite idea of the time required for the passage of the spermatozoids to the ovaries or for the descent of the ovum into the uterus; and it is readily understood how these questions hardly admit of experimental investigation. It is known, however, that spermatozoids reach the ovaries, and they have been seen in motion on their surface, seven or eight days after connection.

Fecundation.—The ordinary situation at which the ovum is fecundated is the dilated, or external portion of the Fallopian tube. All authorities are agreed that fecundation does not take place in the cavity of the uterus. In rabbits, when the ovum has descended into the uterus, it is surrounded with a dense, albuminous coating which the spermatozoids can not penetrate (Coste). It is possible that this occurs in the human subject. Cases of abdominal pregnancy show that an ovum may be fecundated on the ovary, as soon as it is discharged from the Graafian follicle.

The question of the duration of vitality of the spermatozoids, after their passage into the uterus, has an important bearing upon the time when conception is most liable to follow sexual intercourse. The alkaline mucus of the internal organs actually favors their movements; the movements are not arrested by contact with menstrual blood; and, indeed, when the spermatozoids are mixed with the uterine mucus, they simply change their medium, and there is no reason to believe that they may not retain their vitality as well as in the mucus of the vesiculæ seminales. It seems impossible, therefore, to fix any limit to the vitality of these anatomical elements, under physiological conditions; and it is not certain that spermatozoids may not remain in the Fallopian tubes and around the ovary, when intercourse has taken place immediately after a menstrual period, until the ovulation following. There is an idea, based upon rather general and indefinite observation, that conception is most likely to follow an intercourse which occurs soon after a monthly period; but it is certain that it may occur at any time. It is prob-

able that during the unusual sexual excitement which the female generally experiences after a monthly period, the action of the internal organs, attending and following coitus, presents the most favorable conditions for the penetration of the fecundating elements.

Union of the Male with the Female Element of Generation.—In the ova of certain animals, an opening, called a micropyle, has been demonstrated in the vitelline membrane (Barry, Keber). This has been seen in the ova of rabbits, although its existence is to be inferred, only, in the human ovum. The penetration of spermatozoids has been observed in the ova of various animals, including the rabbit (Newport, Coste, Bischoff, Weil, Hensen and others). Weil has seen spermatozoids wedged in the substance of the zona pellucida, has added blood to a specimen under observation, and has restored the movements of the spermatozoids while in this position. Hensen has seen twenty or more spermatozoids within the zona pellucida in rabbits. The number of spermatozoids which penetrate the ovum, according to the most recent researches on fecundation in rabbits, does not seem to be important, as only one spermatozoid forms a direct union with the female generative element. It is assumed that the processes observed in rabbits nearly represent those which take place in the human subject.

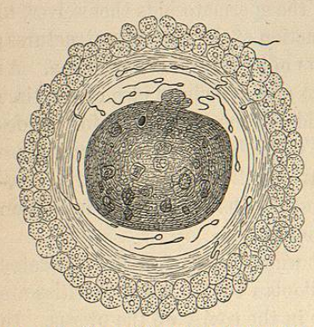

FIG. 291.—*Ovum of the rabbit, showing penetration of spermatozoids and retraction of the vitellus* (Hensen).

In the rabbit, spermatozoids begin to pass through the zona pellucida about thirteen hours after copulation (Hensen). By this time the vitellus usually has become somewhat shrunken and more or less deformed. There is then a space, filled with a clear liquid, between the vitellus and the vitelline membrane, in which the spermatozoids are seen in active movement. The vitelline mass, thus surrounded with liquid, undergoes usually movements of rotation. These phenomena have been described as deformation and gyration of the vitellus. At about this time the germinal vesicle, according to the older writers, disappears; but it has been lately ascertained that this body is concerned in the formation of the polar globule. The retraction of the vitellus and the formation of the polar globule are independent of fecundation; but the formation of the polar globule is a process immediately preparatory to the union of the male with the female generative element, and may properly be described in connection with the mechanism of fertilization of the ovum.

As the deutoplasmic zone extends from the centre toward the periphery of the ovum, the germinal vesicle is pushed outward until it reaches the surface of the vitellus. It then becomes spindle-shaped; and the granules of the vitellus near the extremities of the spindle arrange themselves in the form of stars, forming what has been called the double star, or diaster (Fol). The extremity of the spindle which is near the surface projects and forms a clear, mammillated eminence upon the vitellus. This projection becomes

constricted at its base, and is finally separated in the form of a globule. A second polar globule is afterward formed in the same way.

That portion of the altered germinal vesicle which remains embedded in the vitellus is called the female pronucleus. At the point where the polar globules are separated, a single spermatozoid penetrates the vitellus. The head and intermediate segment of the spermatozoid become surrounded with a star, swell up and form the male pronucleus. The male pronucleus unites with the female pronucleus, and fecundation is complete. The union of the male with the female pronucleus forms a body which passes downward into the substance of the vitellus and is called the vitelline nucleus. The furrow which marks the beginning of segmentation of the vitellus is always observed at the point of separation of the polar globules.

Hereditary Transmission, Superfecundation etc.—The first question which naturally arises relates to the conditions which determine the sex of offspring. Statistics show the proportions between male and female births; but nothing has ever been done in the way of procreating male or female children at will. According to Longet, the proportion of male to female births is about 104 to 105, these figures presenting certain modifications under varying conditions of climate, season, nutrition etc. It has been shown, by observations upon certain of the inferior animals, that the preponderance of sex in births bears a certain relation to the vigor and age of the parents; and that old and feeble females fecundated by young and vigorous males produce a greater number of males, and *vice versâ;* but no exact laws of this kind have been found applicable to the human subject.

No definite rule can be laid down with regard to the transmission of mental or physical peculiarities to offspring. Sometimes the progeny assumes more the character of the male than of the female parent, and sometimes the reverse is the case, without any reference to the sex of the child; sometimes there appears to be no such relation; and occasionally peculiarities are observed, derived apparently from grandparents. This is true with regard to pathological as well as physiological peculiarities, as in the inherited tendencies to certain diseases, malformations etc.

A peculiar and, it seems to be, an inexplicable fact is that previous pregnancies have an influence upon offspring. This is well known to breeders of animals. If pure-blooded mares or bitches have been once covered by an inferior male, in subsequent fecundations the young are likely to partake of the character of the first male, even if they be afterward bred with males of unimpeachable pedigree. The same influence is observed in the human subject. A woman may have, by a second husband, children who resemble a former husband, and this is particularly well marked in certain instances by the color of the hair and eyes. A white woman who has had children by a negro may subsequently bear children to a white man, these children presenting some of the unmistakable peculiarities of the negro race.

Superfecundation of course does not come in the category of influences just mentioned. It is not infrequent to observe twins, when two males have had access to the female, which are entirely distinct from each other in their

physical characters; a fact which is readily explained by the assumption that two ova have been separately fecundated. This view is entirely sustained by observation and experiment. Many cases illustrating this point are on record.

The following communication, with a photograph, was received in January, 1869, from Dr. John H. Janeway, Assistant Surgeon, U. S. A., and it illustrates superfecundation in the human subject; or at least that was the view taken by the negro father:

"Frances Hunt, a freedwoman, aged thirty-five years, gave birth to twins, February 4, 1867, in New Kent County, Virginia. One of these twins was black, the other was white. Frances is a mulatto. The black

FIG. 292.—*Mulatto mother with twins, one white and the other black* (from a photograph).

child is much darker than she is. Previous to the parturition, she had given birth to seven children, all single births. She was living at the time of her impregnation in the family of a white man as house-servant, sleeping with a black man at night. She insists, however, that she never had carnal intercourse with a white man. She probably does this because the black man turned her out of his house when he saw that one of the children was white. The only negro feature in the white child was its nose. There, its resemblance to its mother was perfect. Its hair was long, light and silky. Complexion brilliant."

Reference has already been made to the curious fact that when a cow produces twins, one male and the other female, the female, which is called a free-martin, is sterile and presents an imperfect development of the internal organs of generation. This has led to the idea that possibly the same law may apply to the human subject, in cases of twins, one male and the other female; but many observations are recorded in gynæcological works, showing the incorrectness of this view.

It has long been a question whether impressions made upon the nervous system of the mother can exert an influence upon the fœtus in utero. While many authors admit that violent emotions experienced by the mother may affect the nutrition and the general development of the fœtus, some writers of authority deny that the imagination can have any influence in producing deformities. The remarkable cases recorded as instances of deformity due to the influence of the maternal mind are not entirely reliable; and it often happens that when a child is born with a deformity, the mother imagines she can explain it by some impression received during pregnancy, which she recalls only after she knows that the child is deformed. There is, indeed, no satisfactory evidence that the maternal mind has anything to do with the production of deformities in utero.

CHANGES IN THE FECUNDATED OVUM.

It is probable that the ovum is fecundated either just as it enters the Fallopian tube or in the dilated portion, near the ovary. As it passes down the tube, whether it be or be not fecundated, it becomes covered with an albuminous layer. This layer probably serves to protect the fecundated ovum, and when the spermatozoids do not penetrate the vitelline membrane near the ovary, it presents an obstacle to their passage.

After fecundation of the ovum, at least in many of the lowest forms of animals, the appearance of the vitellus undergoes a remarkable change, by which ova that are about to pass through the first processes of development may readily be distinguished from those which have not been fecundated. This change consists in an enlargement of the granules and their more complete separation from the clear substance of the vitellus. The granules then refract light more strongly than before, so that the fecundated ova are distinctly brighter than the others.

Segmentation of the Vitellus.—Soon after the fecundation of the ovum and the formation of the vitelline nucleus, a furrow appears at the point of extrusion of the polar globules. This is met by a furrow upon the opposite side, and the vitellus is divided into two globes. One of the globes is slightly larger than the other, and presents fewer and smaller granules. The larger sphere subsequently forms, by its division, the epiblastic cells, and the smaller sphere forms the hypoblastic cells. Each sphere is provided with a distinct nucleus. The two spheres resulting from the first segmentation of the vitellus are divided, each one into two, making four spheres. These spheres are again divided into eight—four epiblastic and four hypoblastic spheres—each with a nucleus (Van Beneden). One of the